APPLICATION OF PHASE SPACE TECHNIQUE TO THE ANALYSIS OF CARDIOVASCULAR SIGNALS

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Abstract – This paper proposes a new method based on phase space technique for the analysis of cardiovascular signals. The method is based on finding a measure which depends on the distribution of signals in phase space. Results obtained tend to support the feasibility of the proposed method in possibly detecting abnormal conditions in cardiovascular signals .

Keywords- Cardiovascular signals, phase space

I. INTRODUCTION

Recent developments in the theory of nonlinear dynamics have paved the way for analyzing signals that originate from complex living systems. Nonlinear dynamical analysis of heart rate and respiratory signals has been made so as to improve the understanding of the underlying physiological processes of the autonomous nervous system[1]. It has been found that the application of the approach involving ECG signals also show promise[2]. The present work is concerned with the use of a nonlinear dynamical technique for the analysis of various cardiovascular signals. A new method based on phase space technique is presented and its use in monitoring cardiovascular status of patients is demonstrated.

II. METHOD

From the given digitized data x(1),x(2), ... ,x(n) of the cardiovascular signal of interest , a matrix A is obtained with its two columns given by x(1) ,x(2),...x(n-τ) and x(1+τ), x(2+τ),... x(n) . The matrix A is normalized and the phase space area is divided into small square grids. The sum of squares of the phase space points falling in a grid g(i,j) is calculated and is normalized with respect to the number of data points to obtain S. The parameter S can be used as a measure to quantify the structure of the signals as well as to differentiate between different patterns of the signals.

III. RESULTS AND DISCUSSIONS

The proposed method has been applied to samples of Heart Rate Variability(HRV),Electrocardiogram(ECG) and Arterial Blood Pressure(ABP) signals taken from MIT-BIH database. First , two HRV signals whose dynamics differ significantly have been considered and the proposed method gave values of S equal to 414.7 and 610.9 respectively thus detecting the change in the dynamics of the signal.Next, the method has been applied to normal and pathological ECG and ABP signals derived from the data base. The phase space plots of ABP signals for normal and pathological cases are shown in Fig. 1 and Fig. 2 respectively. It may be observed from Fig. 1 that the number of phase space points are distributed in less number of grids available in the normalized phase space. The same number of phase space points are distributed in more number of grids in Fig.2.Application of the proposed phase space method gave a value of S equal to 618 for Fig. 1 and 864 for Fig.2.Similar observations have also been made with other cardiovascular signals .

IV. CONCLUSIONS

A new phase space technique for quantifying the distribution of phase space points has been developed and its use in differentiating the patterns in cardiovascular signals has been tested. Results obtained show that the method show promise in detecting abnormal conditions in cardiovascular signals . It can be of great use in monitoring cardiovascular status of patients in critical care unit. Its use as a parameter in multimodal data fusion system is being investigated.

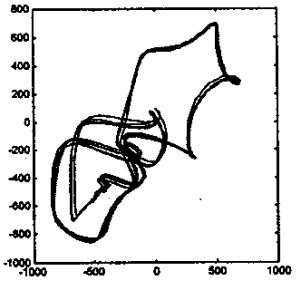

Fig.1

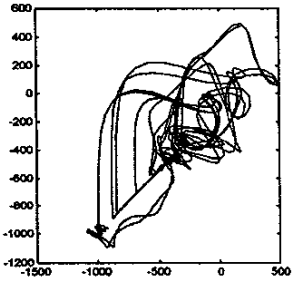

Fig.2

Fig 1. Phase space plot of normal ABP signal
Fig.2 Phase space plot of abnormal ABP signal

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